Innovation: Teaching Ideas For Using Children's Literature In Mathematics Lessons

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Abstract
The use of children's literature in mathematics lessons has received widespread attention recently, with a growing collection of articles written about it. Many of these articles discuss the benefits of integrating literature and mathematics. Hence there seems to be ample reasons for using children's literature as a vehicle for mathematics learning. Given the fact that using children's literature in mathematics lessons may not be a common practice in Singapore schools, this paper aims to offer teachers some teaching ideas for designing a mathematics lesson around literature.

Introduction

The recent implementation of the *Innovation and Enterprise* (I & E) initiative appears to draw attention to new learning activities to be carried out in the classroom. The term *innovation* seems to presuppose introducing new and original classroom activities into lessons. But it does not always have to be so. In fact, this term can refer to conducting existing activities in a different way, and it is this latter interpretation of the term that forms the basis of the learning activities described in this article.

This article offers two detailed teaching ideas designed to illustrate how an existing school programme such as the reading programme can be integrated with a mathematics lesson using literature. The article begins with a discussion of the benefits of connecting literature and mathematics to enhance student learning, and follows with a description of the teaching ideas.

The Value of Connecting Literature and Mathematics

The use of children's literature in mathematics lessons, although not actually a new idea, is relatively uncommon in Singapore schools. In fact, integrating literature into mathematics lessons is quite a common practice that is strongly endorsed by mathematics educators in the United States. In recent years, there has been a growing collection of articles written about it, with most of them pointing to its benefits. Thus, the remaining section highlights the potential that children's literature holds for teaching mathematical concepts.

Literature can help students build bridges between mathematics and the real world. According to Moyer (2000), literature with mathematics in a context familiar to children makes sense to them because they can relate the mathematical idea mentioned in the story to their everyday experiences. She cites from *The Doorbell Rang* by Hutchins (1986) to illustrate how the story in which the characters share a fixed number of cookies with varying number of people provides a familiar setting that allows children to connect the concept of division to a real-world situation.

In a way, Moyer's example also seems to point to another potential of using literature in the mathematics classroom. That is, literature can provide a meaningful context to the learning of mathematics in the classrooms. An example that illustrates this benefit and is suitable at the primary level is provided by Murphy (1999). He cites the story of a young girl describing how she and her grandmother make jewellery from all kind of beads from *A String of Beads* (Reid, 1997). This story, covering skills such as counting, sorting, classifying and making patterns, not only broadens the children's experiences but affords them opportunities to perceive mathematics as "a useful tool for solving problems" (Whitin, 1992, p. 24) as well. Another manifestation of this benefit, but at the secondary level, is exemplified by Austin, Thompson and Beckmann (2005). Using *The Librarian Who Measured The Earth* by Lasky (1994), they elaborate how the story can offer an appropriate setting to examine the concept of estimation and the degree of accuracy when children learn about a possible way of determining the circumference of the Earth based on the distance between two cities.

Finally, the processes of reading can support the processes of mathematical problem solving. Skills typically associated with reading such as making inferences and drawing conclusions are also important tools for logical deduction in problem solving. As the above discussion makes clear, integrating children's literature into the mathematics classrooms holds promise not only for providing a context through which mathematical concepts can be explored but also as a potentially powerful teaching tool for developing and enhancing children's understanding of mathematical concepts. Consequently, the benefits aforementioned seem to give ample reasons for using children's literature as a vehicle to make mathematics more meaning and interesting to learn.

Numerous books can be used to develop mathematical concepts. In this article, the two books selected to develop the literature-based learning activities are *The Number Devil* by Enzensberger (2000) and *Encounters with Animals* by Durrell (1963). A brief summary about each book and the outline of the respective learning activities follow in the remaining sections.

The Books and The Learning Activities

The Number Devil

The Number Devil (Enzensberger, 2000) tells the story of a 12-year-old boy, named Robert, who hates Mathematics because his mathematics teacher disallows calculators in class. One day, Robert begins to dream about a small, red and fiery-tempered creature with a passion for numbers, called the Number Devil, who teaches him different mathematical ideas and concepts in an interesting and fascinating way. Over a period of twelve different nights, Robert learns about simple mathematical ideas such as fractions, the importance of zero, prime numbers, Fibonacci numbers, triangular numbers, and square numbers. Additionally, Robert also learns about more complex mathematical ideas like factorials, imaginary numbers as well as the concept of infinity.

On the fifth night, the Number Devil presents the idea of square numbers to Robert in his dream. Using ice cubes, the Number Devil shows Robert what square numbers are by building five shapes on the table (see Figure 1). Each shape, in the form of a square, is made up of different number of ice cubes. The first shape is made up of one ice cube, the second four ice cubes, the third nine ice cubes and so on. The Number Devil then explains how the number of ice cubes used to make each shape can be determined from the number of ice cubes on one side of the shape. For instance, the third shape has three ice cubes on one side and, therefore, the number of ice cubes used to make this shape is $3 \times 3 = 3^2 = 9$.

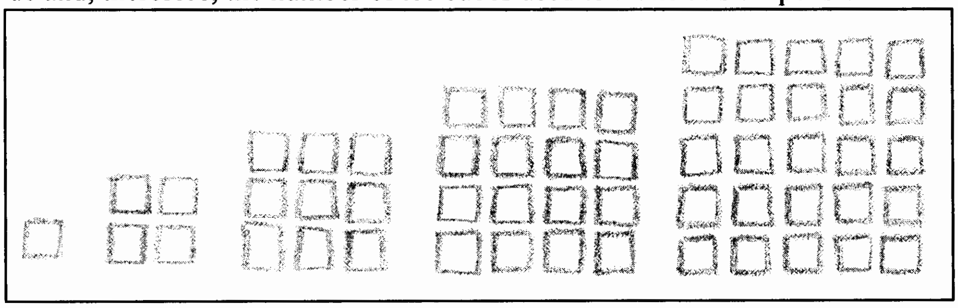


Figure 1. Shapes built from ice cubes

Immediately following this explanation is a simple problem for readers to work out (see Figure 2). This problem, although straightforward, actually contains an interesting relationship between two kinds of numbers. However, this relationship is not explicitly highlighted in the problem, and it can be rather inconspicuous for students to discover it without any teacher's guidance. Consequently, this problem can provide rich points for classroom exploration and discussion to establish this relationship that links square numbers and consecutive odd numbers. Therefore, in the remaining section, I will describe a classroom activity built upon this problem and illustrate how it can lead students to uncover the relationship between square numbers and consecutive odd numbers by means of performing some tasks. The learning theory underpinning this activity is described by Chua and Ng (2004) in their article ***Square Numbers: Their bonds with odd numbers***.

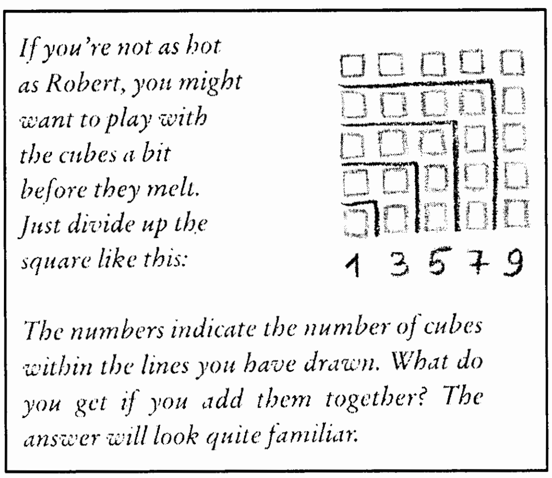


Figure 2. A task for readers

The Activity. Instead of using ice cubes as mentioned in the book, students will use square tiles to perform the tasks given in the table below.

Manipulating and getting a sense of the pattern	1. Use square tiles to make the five shapes as shown in Figure 1. 2. Labelling the shapes as Shape 1 to Shape 5 respectively from left to right, describe how you would make Shape 2 from Shape 1, Shape 3 from Shape 2, Shape 4 from Shape 3, Shape 5 from Shape 4. 3. Describe how you would make Shape 6 from Shape 5.
Articulating the pattern	4. Without using the square tiles, describe how you would make Shape 10.
Generalising the pattern	5. Find the sum of the first n consecutive odd numbers.

When students express how they make the shapes, it is important for them to describe what they see as a series of growing consecutive odd numbers and not as an outcome. For instance, the number of square tiles used to make Shape 3 is $1+3+5$ and not 9 or $4+5$. This mode of description should continue for Shapes 4, 5, 6,10 and so on. From Shape 3, teachers can lead students to recognise that the sum of the first three consecutive odd numbers is 3^2 and 3 is actually the shape number. To consolidate the pattern they see, teachers can also encourage students to test the pattern with Shapes 4, 5, 6 and 10.

Further consolidation may take place if students are asked to identify the shape number given the series of consecutive odd numbers such as $1+3+5+...+25$. With this, a link could be made between the shape number and the number of consecutive odd numbers in the series as well as between the first and last terms of the series. For instance, the number of consecutive odd numbers in $1+3+5+...+25$ is 13 which is the shape number! It is interesting to highlight that this shape number also corresponds to the mean of the first and the last terms of the series. Hence, given any shape number, the last term of the series of this shape could be determined. Take Shape 20 as an illustration. Without having to list the entire series, students should ideally be able to state that the last term of the series is $2\times 20-1=39$.

So, what is the sum of the first *n* consecutive odd numbers? The answer is clearly n^2! However, knowing this answer may not be sufficient. Take the case of finding the sum of $1+3+5+...+357$. Finding its answer is not so trivial. In order to answer this question, it is necessary for students to find out the number of terms in the series. This is where it is important for them to identify that the last term of the first *n* consecutive odd numbers is $2n-1$. In this case, $2n-1$ is equivalent to 357 and with this relationship in place, the value of *n* can be found. Hence, the sum of $1+3+5+...+357$ can then be determined.

Encounters with Animals

The book *Encounters with Animals* by Gerald Durrell (1963) amasses all the talks on various animal subjects he made for the British Broadcasting Corporation (BBC). Durrell is a naturalist and zoo preservationist who, apart from collecting animals for British zoos, observes and studies their eating habits, their habitats and temperaments. In this book, he recounts captivating tales of the courtships, wars and characters of animals that he encountered in various places around the world. With his knack of describing animals, entertaining details of their habitats, antics and special skills are presented vividly.

In the chapter Animal Inventors, Durrell recounted an incident that happened on a ship when he was travelling back from Africa after his animal collection trip. The Irish ship captain, after listening to a radio talk on radar, which was relatively new to the public in those days, bet with Durrell to identify four scientific inventions whose principles were being used in the animal world long before they were invented. Of course, this challenge posed no threat to Durrell! Since they were on the subject of radar, Durrell described the humble bat as his first example. He remarked that a bat's swift and skilful flight and the rapid twists and turns with which it avoids all obstacles was not fully investigated and understood until the discovery of radar. It has been found that as a bat flies along, it emits supersonic squeaks that are inaudible for the human ears. When a squeak hits an object, an echo bounces off and the bat can then identify the object by the sound of the echo. The bat can even tell the size and shape of a tiny insect from its echo. Durrell was amazed not only by the fact that bats use echolocation to navigate in the dark, but that they have possibly been using radar for a very long time before it was discovered by man, based on the fossil bats found in rocks, which did not differ very much from their modern relatives.

The topic on bats should invoke keen interest among students because of their possible association with vampires. So, teachers can encourage students to collect facts about bats such as the various species, their lengths and weights as well as what they eat. Using these students' data, suitable classroom activities can then be designed to teach or review fundamental mathematical ideas such as arithmetic and statistical concepts. However, since spatial visualisation can help stretch students' minds and make them more flexible and creative, I shall illustrate a motivational learning activity for geometry using the topic of bats in this article.

The Activity. The classroom activity involves students working on tangrams. The tangram is an ancient Chinese geometric seven-piece puzzle with two large triangles, one medium triangle, two small triangles, one square and one parallelogram. Instead of using commercial plastic tangram sets, give students a tangram template and have them cut out the pieces. One benefit of using the tangram template over the commercially produced set is that such an activity can provide students a rich experience in discussing different concepts of geometry like sizes, angles, shapes, congruency and similarity. Once the template has been cut out, get students to arrange all the seven pieces to create a given figure of a bat. Finally, students' imagination and creativity will be unleashed when they construct their own figure of a bat using all the pieces. The tasks and skills involved in this activity are presented in Table 2.

Table 2

The Tangram Tasks and Skills Involved

Skills	Tasks
Geometry: recognise and name shapes, identify properties of shapes, apply Pythagoras' theorem to compute lengths *Arithmetic*: identify and compare fractions	1. Cut out the tangram template in Figure 3 into the seven pieces. 2. Name the various shapes. 3. What fraction of the template is the large triangle? Medium triangle? Small triangle? Square? Parallelogram? 4. If the small square has an area of one square unit, what are the respective areas of the other pieces? What are the dimensions of each shape?
Geometry: spatial visualisation, compute the area and perimeter of shapes *Thinking skill*: spatial visualisation	5. Use all the seven pieces to make the figure of a bat as shown in Figure 4a. 6. If the small square has an area of one square unit, what is the area of the bat? 7. What is its perimeter?
Thinking skill: spatial visualisation	8. Use all the seven pieces to make your own figure of a bat. 9. Paste your bat on a piece of A4 paper. 10. What can you say about the areas of your bat and the one shown in Figure 4? 11. Find the perimeter of your bat?

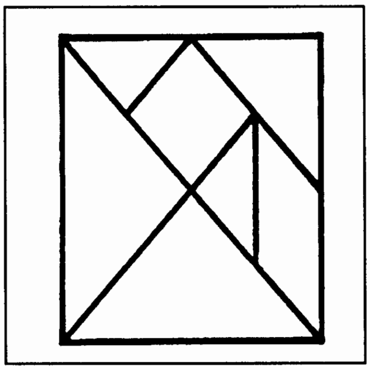
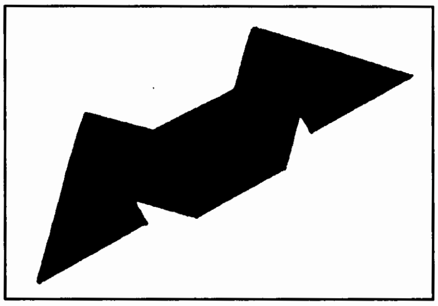
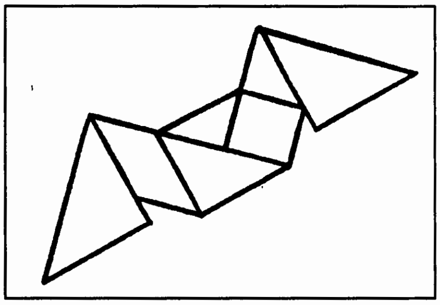


Figure 3. The tangram template



(a) without helplines



(b) with helplines

Figure 4. A bat.

When students are cutting out the tangram template into pieces, it may be helpful to remind them of the need for precision although it is occasionally inevitable of any practical activity to have slight imperfections due to carelessness. In naming the various shapes, students should be encouraged to use proper terminologies and provide a brief justification for their answers. For instance, a student can explain that the large triangle is called an isosceles right-angled triangle because its two acute angles are 45^0 each. When explanation such as this one is continued until all the shapes are named, students may be able to recognise that all the angles are either right angles, 45^0 or 135^0. Other than this, it is also essential for them to be able to realise and justify that the two large triangles, along with the two small triangles, are congruent, and that the large, medium and small triangles are similar to each other.

Additionally, a connection between arithmetic and geometric concepts can be established as numerical equivalences emerge during the process of cutting the tangram template into the various pieces. This is where teachers can ask questions that lead students to identify this connection. To illustrate how this can be done, students can be guided to infer that since the two large triangles are congruent and make up one half of the whole square, each large triangle is therefore a quarter of the whole square. In a similar manner, students can then be prompted to deduce that the medium triangle, the small square and the parallelogram are each an eighth of the whole square, and that each small triangle is a sixteenth. With this, teachers can review and consolidate the concept of fractional parts with students. Further consolidation may take place in the form of asking students to fit two small triangles above the parallelogram to illustrate the idea that two sixteenths make an eighth.

Apart from developing the concept of fractional parts, proportional reasoning is another essential skill to promote because students often make sense of the world around them through comparisons of various objects. To develop this skill, teachers can ask students to find the areas of the other pieces if the small square is assumed to be one square unit in area (Part (4) of Table 2). With this given fact, students can infer that the medium triangle and parallelogram have the same area as the small square because all are an eighth of the whole square. Similar inference can also be drawn about the areas of the small and large triangles. Summing up the areas of all the pieces will then give the area of the whole square. To be able to find the area of the bat as is required in Part (6) of Table 2, students will have to deduce that it has the same area as the whole square because the bat has been made from the same set of tangrams using all the pieces. Following the same reasoning, students should also realise that the areas of the two bats formed in Parts (5) and (8) of Table 2 are equivalent as well.

Conclusion

Integrating children's literature with mathematics provides opportunities to motivate students in their learning of mathematics and also offers mathematics teachers a means to collaborate with their colleagues teaching English and English Literature. With the many perceived benefits that come with such a practice, local teachers are encouraged to explore the use of literature in their mathematics teaching to enrich their students' lives as well as to enhance their appreciation of mathematics. For those who like to try out this practice, the two learning activities described here can serve as a springboard for them. However, they should note that the activities are designed for lower secondary students and the mathematics levels of these activities can be revised appropriately to meet the learning needs of students in the other levels.

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